METHOD AND APPARATUS FOR WARNING A FOLLOWING VEHICLE DURING BRAKING

Background of the Invention

The present invention relates to a method and apparatus for warning a following vehicle when a vehicle in front, a leading vehicle, applies its brakes.

DE 43 05 186 C2 discloses a method for reducing the danger of rear end accidents in traffic via a deceleration warning; this document also discloses a deceleration warning system. During a braking process, an integral is formed via the deceleration, and as a result a danger value is calculated in conformity with which the signal aspect or pattern of a brake light is affected. After conclusion of a deceleration, the brake light is not immediately distinguished; rather, the lights thereof fade in conformity with a predetermined function or equation. A characteristic of such integral brake lights is that short, pronounced decelerations of the leading vehicle are only presented after a time delay that is due to the integration; this can lead to dangerous situations if traffic is heavy.

Methods for warning a following vehicle are also known where one or more brake lights of a leading vehicle are illuminated in conformity with the present deceleration, and in particular proportionally to the present deceleration. In this connection, the size of the illuminating surface and/or light intensity thereof can vary in

conformity with the present deceleration. Such proportionally controlled brake lights generally extinguish immediately after conclusion of the deceleration. A characteristic of the brake lights that illuminate proportionally to the deceleration is that their signal pattern is very uneven due to the deceleration, which generally rapidly varies during a braking process. Furthermore, they draw considerable attention of the driver of a following vehicle even if the braking of the leading vehicle does not present a great danger, for example during very brief, intense decelerations that do not lead to significant reductions in speed. In contrast, at the conclusion of a lasting deceleration, there is no longer a warning, although the braking vehicle presents a great danger to the following vehicle, which is still driving faster.

It is therefore an object of the present invention to provide a method and an apparatus for warning a following vehicle when a vehicle in front applies its brakes, whereby the aforementioned drawbacks are to be overcome and an effective measure is to be provided for reducing rear end accidents.

Brief Description of the Drawing

This object, and other objects and advantages of the present invention, will appear more clearly from the following specification in conjunction with the accompanying schematic drawing, in which:

Fig. 1 is a simplified block diagram of one exemplary embodiment of the inventive warning apparatus;

Fig. 2 is a view upon a brake light;

Fig. 3 shows curves for explaining the function of the present invention.

Summary of the Invention

The method of the present invention is characterized primarily by:

causing at least one brake light of the leading vehicle to illuminate during a braking process, as a braking value of the braking process increases, in conformity with a present value of the braking value;

causing illumination to last for a retention time that is a function of the braking process in conformity with a maximum value of the braking value after such value drops below the maximum value; and

causing the illumination to fade, after conclusion of the retention time, during a period of time that is a function of the braking process.

The method of the present invention is characterized in that during the braking process, at least as long as a characteristic braking value does not drop, the signal pattern of the brake light, and hence the warning thereof, is provided by the maximum value of the braking value. If the value drops below this maximum braking value, then despite the decreasing braking value the braking lights initially continue

to illuminate in a non-modified manner during a retention time, and are then extinguished within a fading time that is a function of the braking process. The characteristic braking value can relate to the vehicle deceleration, the braking pressure, the actuation force of a brake pedal, the actuation path of the brake pedal, or some other value that is characteristic for the braking process.

With the inventive method, an easy to comprehend warning is generated that corresponds to the danger represented for a following vehicle by a vehicle in front that is applying its brakes. In addition, the method of the present invention is straightforward and economical.

The apparatus of the present invention is characterized primarily by at least one brake light, for the leading vehicle, having a variable signal pattern; a control device having a computer; and means for conveying to the control device at least one present braking value that characterizes a braking process, wherein the computer calculates a control value such that the at least one brake light will be illuminated and will fade in conformity with the method of the present invention.

During the fading duration, the control value that determines the fading can be compared with a control value that corresponds with an illumination of the brake light in conformity with the respective momentary braking value, and such momentary braking value can be taken as the new maximum braking value if the control value that determines the fading is the same or less than the value corresponding

to the momentary braking value. As a result, the warning provided by the brake light during a long lasting braking process in every case lasts beyond the conclusion of the vehicle deceleration, even if during a braking process a value is obtained that drops below a maximum braking value.

Further specific features of the present invention will be described in detail subsequently.

Description of Preferred Embodiments

Referring now to the drawing in detail, as can be seen from the block diagram of Fig. 1 speed sensors 2 that are disposed on the wheels of a motor vehicle are connected to a control device 4 that in a manner known per se contains a microprocessor with pertaining memory. Connected to the control device 4 is an actuation sensor 6 that detects the actuation of a brake pedal 8. A line 10 leads from the control device 4 to conventional rear brake lights 12 that light up in a known manner as soon as the brake pedal 8 is actuated. In addition, a signal line 14 leads from the control device to a brake light 16 that extends over a portion of the width of the vehicle and pursuant to Fig. 2 is embodied as a band of lights or lamps composed of individual light emitting diodes a to o.

The construction and function of the individual components or groups of components are known and will therefore not be described in detail. The control can be modified in many different ways; for

example, the control device 4 can be embodied in the form of several, decentralized control units, one of which controls an ABS braking system of the vehicle, another can control the drive train (engine and transmission), and a third one can control the electronics of the vehicle (lights, central locking mechanism, etc.). The individual control units can communicate with one another via a bus system. In the illustrated embodiment, an interface is disposed in the brake light 16 that with the aid of the data transmitted over the data line 14 activates the electronic switch associated with the individual light emitting diodes so that in conformity with the data sent over the signal line 14 more or fewer diodes of the brake light 16 light up. Fig. 2 illustrates a condition where the two outermost light emitting diodes at each end are illuminated.

The present invention, which is reflected, for example, merely in the programming of the microprocessor contained in the control device 4, or in individual hardware, will be explained with the aid of Fig. 3 as follows.

The solid curve represents for a braking process the deceleration "a" as a function of time "t". As can be seen, in the illustrated embodiment the deceleration "a" first increases sharply and reaches a maximum value a_{max} . Proceeding from the maximum value a_{max} , which is achieved at the point in time t_1 , the maximum deceleration lasts until the point in time t_2 , and then drops in a varying

sharp manner to a value of zero, which is achieved at the point in time t_e , at which the braking process is concluded.

The dashed-line curve represents a control signal calculated in the control device 4 for activating the brake light 16. This control signal corresponds to the warning intensity that emanates from the brake light 16 in that, for example, the greater the control signal the more diodes are illuminated.

As can be seen, the control signal "s" follows the deceleration "a" as long as the latter rises (up to the point in time t_1) or remains constant (up to the point in time t_2). When the deceleration drops (after the point in time t_2), the control signal "s" first remains constant at its value s_{max}, which corresponds to the value a_{max}. The so-called retention time Δt_h , during which the control signal, and hence the signal aspect or pattern of the brake light 16, remains unaltered, is in the illustrated embodiment determined by the time interval between t_2 and t_3 , whereby t_3 is that point in time at which the deceleration "a" has dropped to half of the maximum value. As soon as the point in time t_3 is reached, the control signal drops with a predetermined change in terms of time; in other words, in the illustrated embodiment light emitting diodes of the brake light 16 are increasingly extinguished.

In the embodiment illustrated in Fig. 3, the signal value "s" does not drop continuously to zero, but rather, starting at the point in time $t_{2'}$,

again remains at a constant value $s_{max'}$, in order starting at the point in time $t_{3'}$ to drop to zero at the prescribed fading speed.

The point in time $t_{2'}$ occurs when the value of the control signal "s", which drops at a prescribed fading function, drops below the value that the control signal has corresponding to the acceleration "a" at the point in time $t_{2'}$. The intersection value $a_{max'}$ is taken as the new maximum value. The control signal remains at the corresponding value $s_{max'}$ up to the point in time $t_{3'}$, at which the deceleration has dropped to the value $a_{max'}/2$, and then drops in conformity with the predetermined fading function. In this way, the warning of the brake light 16 that corresponds to the control signal in each case lasts over the duration of the vehicle deceleration.

The functionality described can be realized by an appropriate programming of the microprocessor contained in the control device, and storage of the respective values a_{max}.

The coordination between the signal value "s" and the signal pattern of the brake light 16 can be such that with very high values of a_{max}, for example values that are in the vicinity of $10 m/s^2$, all of the light emitting diodes illuminate or even flash, and as the signal value decreases an increasing number of light emitting diodes are extinguished starting from the middle of the brake light 16.

It is to be understood that other types of brake lights having a variable signal pattern can be utilized, for example brake lights the light

intensity of which varies, the illumination surface of which varies in another fashion, etc. The outer brake lights 12, which in the embodiment of Fig. 1 have a conventional configuration, can also be drawn into the deceleration-dependent control in that, for example, their intensity or their surface can also be varied.

Many different possibilities exist for the coordination between deceleration and signal value or signal pattern of the brake light, for example, linear coordination, progressive coordination, diminishing coordination, etc.

The retention time Δt_h can continue in a varied manner until the deceleration has dropped to more or less one-half of the maximum deceleration. In this connection, the vehicle speed at the beginning of the braking process ($t = 0$) can additionally be taken into account at the point in time t_1 or even at the point in time t_2. The vehicle speed is always known by analyzing the speed signals of the wheel sensors. Furthermore, the control device 4 can be designed in such a way that upon activation of an ABS braking system (not illustrated; can be integrated in the control device 4), the vehicle deceleration "a" is set to a value of $a = 10 m/s^2$, which represents a maximum value. In order not to take into account the ABS activation already when the braking of only one wheel is triggered by the ABS system, the system can be embodied in such a way that the ABS activation leads to establishment of the deceleration to a maximum value of $10 m/s^2$ only if two wheels

that are disposed diagonally relative to one another, or three or four wheels, are simultaneously triggered by the ABS system. This has the advantage that the signal pattern is influenced by the ABS system only if the roadway upon which the vehicle is driving is slippery all over.

To determine the vehicle speed, if this enters into the algorithm for determining the retention time and/or the fading function, the point in time can be selected at which the vehicle deceleration exceeds a predetermined threshold value, or that point in time at which the conventional brake light is activated by the brake pedal or the braking pressure.

The fading curve of the signal value "s", which in Fig. 3 is indicated linearly and which determines the extinction of the brake light, or in the case of Fig. 3 co-determines, can be determined according to very different points of view depending upon application. The fading function can be fixed in such a way that the fading time t_a (the duration between t_3 and the dropping "s" to zero, in the event due to continuous deceleration a new value $s_{max'}$ is not set (Fig. 3)), is, for example, the function of v_0 and/or a_{max}, where v_0 is the speed at the beginning of a braking process, upon reaching the maximum acceleration or upon dropping below the maximum acceleration. For example: $t_{al} = kv_0$ or $t_a = ka_{max}$ or $t_a = kv_0a_{max}$ $t_a = kv_0^X a_{max}^y$ or $t_a = k(v_0^x + a_{max}^y)$, or pursuant to some other function. The fading function can also be determined in such a way that the fading time t_a is a function of v_0, a_{max} and t_{0max},

whereby t_{0max} is the duration during which the maximum deceleration is present (duration between t_1 and t_2).

The iteration of the fading of "s" illustrated in Fig. 3 is not mandatory; for example, t_3 can be fixed such that "a" has already dropped to a small value, so that with a slowly decreasing fading function "s", the brake light in practical operation is then completely extinguished only after the deceleration has dropped to at least nearly zero.

It is to be understood that the system illustrated in Fig. 1 can be of a digital or also of an analog type, whereby the signal line 14 in an analog setting leads to a signal, the amplitude of which varies with the acceleration.

The specification incorporates by reference the disclosure of German priority document 199 40 080.6 of 24 August 1999.

The present invention is, of course, in no way restricted to the specific disclosure of the specification and drawings, but also encompasses any modifications within the scope of the appended claims.